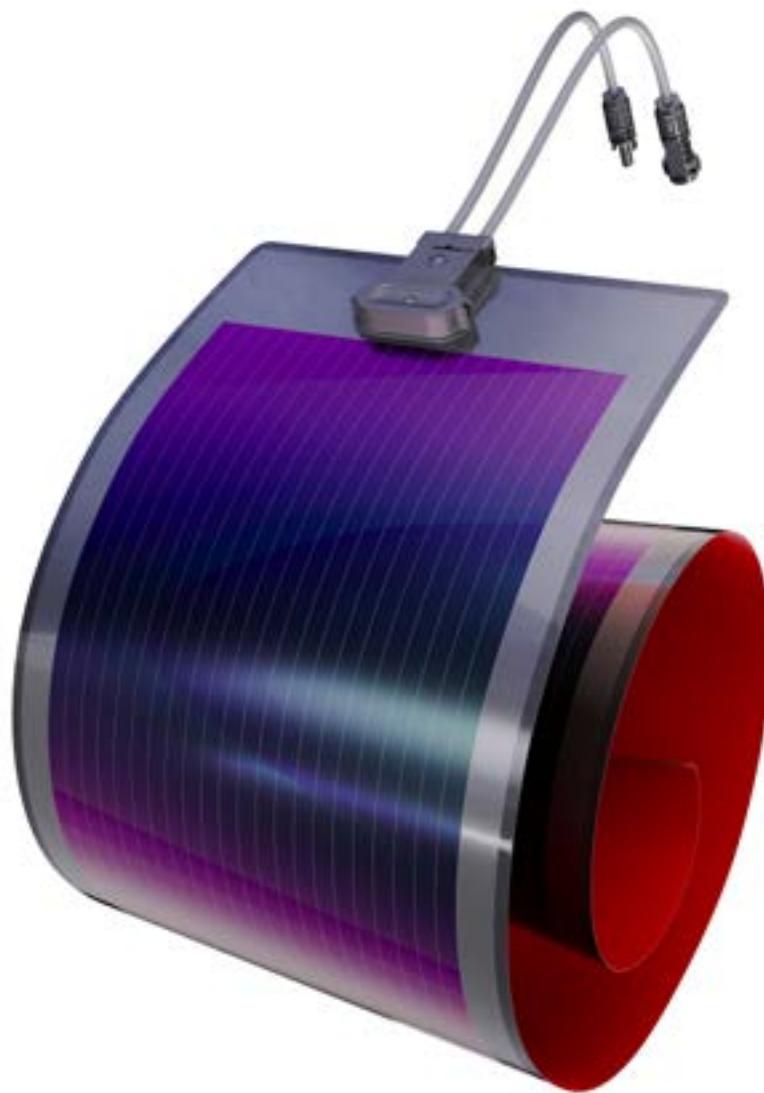




USER GUIDE

HELIASOL® 436-2000



Contact Information:

Please visit our website www.heliatek.com or contact us directly:

Heliatek GmbH
Treidlerstraße 3
01139 Dresden
Germany
Tel: +49 (0) 351 213 034 30
Mail: sayhello@heliatek.com

Publishing Information:

Heliatek GmbH
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01139 Dresden
Germany

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IMPORTANT

Please read this User Guide fully before use and act accordingly. Always keep this User Guide available for future references. Modifying Heliatek's recommended steps may lead to endangerment of life, physical health and loss of property to yourself or other parties. All risks mentioned in this User Guide are not conclusive and do not preclude careful and cautious handling of the product. The warranty conditions will be voided if the instructions of this User Guide are not strictly observed. Always act according to your local regulations. Heliatek will not assume any liability for damage arising from improper use, wrong assembly, operation, maintenance, removal, and disposal. In case of doubt, the consent of Heliatek must always be obtained first. If you have any questions or problems understanding any part of the User Guide, please contact us, before proceeding with your actions.

You find our contact information in this document and on our website: www.heliatek.com

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1 GENERAL INFORMATION

HeliaSol is an innovative organic solar film for the generation of electrical energy from sunlight, designed and tested according IEC 61730:2016 class II, for an environmental temperature range of -40°C to 85°C. It is a ready-to-install product, already equipped with a junction box and plugs on the front and an integrated backside adhesive on the backside for quick and easy installation. Hereinafter HeliaSol is referred to as solar film and describes the entire product.

This User Guide shall give you all the information needed to handle HeliaSol properly and safely. You will find all necessary information about safety, storage, installation, operation, maintenance, removal, and disposal of the solar films in the following chapters. Please ensure that the User Guide is accessible and that it is handed over to the specified person responsible for the operation of the system in the event of a change of ownership or user.

This User Guide does not describe the applicable guidelines for the design, approval, installation, and operation of photovoltaic systems. Be sure to be compliant with all relevant local and national laws, regulations, and codes when installing, wiring, operating, maintaining, and dispose of the solar films. Please read the User Guide carefully and follow every single step as described, so that the solar films are not experiencing any damage and no person(s) is exposed to the risk of injury. Please read all the other applicable documents, such as the datasheet and warranty conditions.

ATTENTION

The warranty conditions will be voided if the instructions of this document are not strictly observed.

Heliatek will not assume any liability for damage arising from improper use, wrong assembly, operation, maintenance, removal, and disposal.

Read each chapter carefully before following every single step, so you do not miss any safety information. You can find the main safety instructions in section 4.1 and throughout the User Guide additionally marked and highlighted.

Heliatek is not liable for all those actions contrary to those granted in this User Guide, including without limitation to improper storage, installation, operation, maintenance, removal, and disposal.

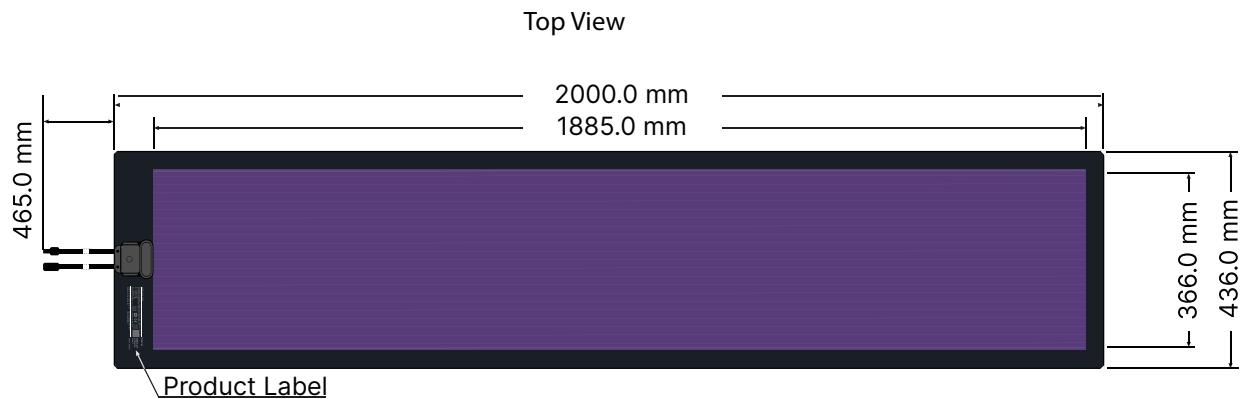
2 SOLAR FILM SPECIFICATIONS

For the electrical specifications please see the relevant datasheet or contact us directly:

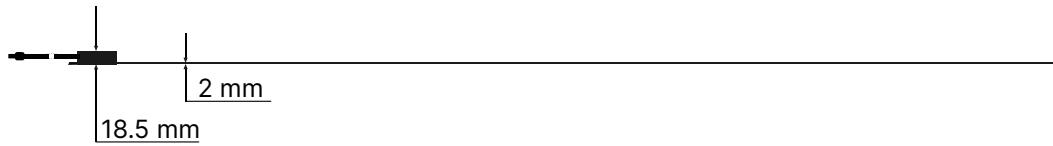
MECHANICAL SPECIFICATIONS	
Module Width	436 mm
Module Length	2000 mm
Thickness	2 mm (solar film) 18.5 mm (solar film plus junction box)
Minimum Bending Radius	50 cm (unidirectional curved surfaces only)
Module Weight	1.6 kg
Load Ratings	Design load: ± 1600 Pa Test load: ± 2400 Pa Safety factor: 1.5

SYSTEM INTEGRATION	
Max. System Voltage	1000 V
Bypass Diodes	1 per solar film
Electrical Connection	TE Connectivity PV4-S connector
Class	II (IEC 61140) <input checked="" type="checkbox"/>
Junction Box	IP67
Inverter Recommendation	<p>Compatibility with all mainstream inverters.</p> <p>Parallel and serial connection of the solar films is allowed within the range of system voltage and considering the max. ratings of all system components.</p> <p>More details in section 4.6 and 4.7.</p>

TECHNICAL DRAWING



Side View



For further information please see the relevant datasheet or contact us directly.

PRODUCTS RELATED TO THIS USER MANUAL

The information mentioned in this User Guide is relevant for the following models of HeliaSol 436-2000:

- HeliaSol 436-2000-45
- HeliaSol 436-2000-50
- HeliaSol 436-2000-55

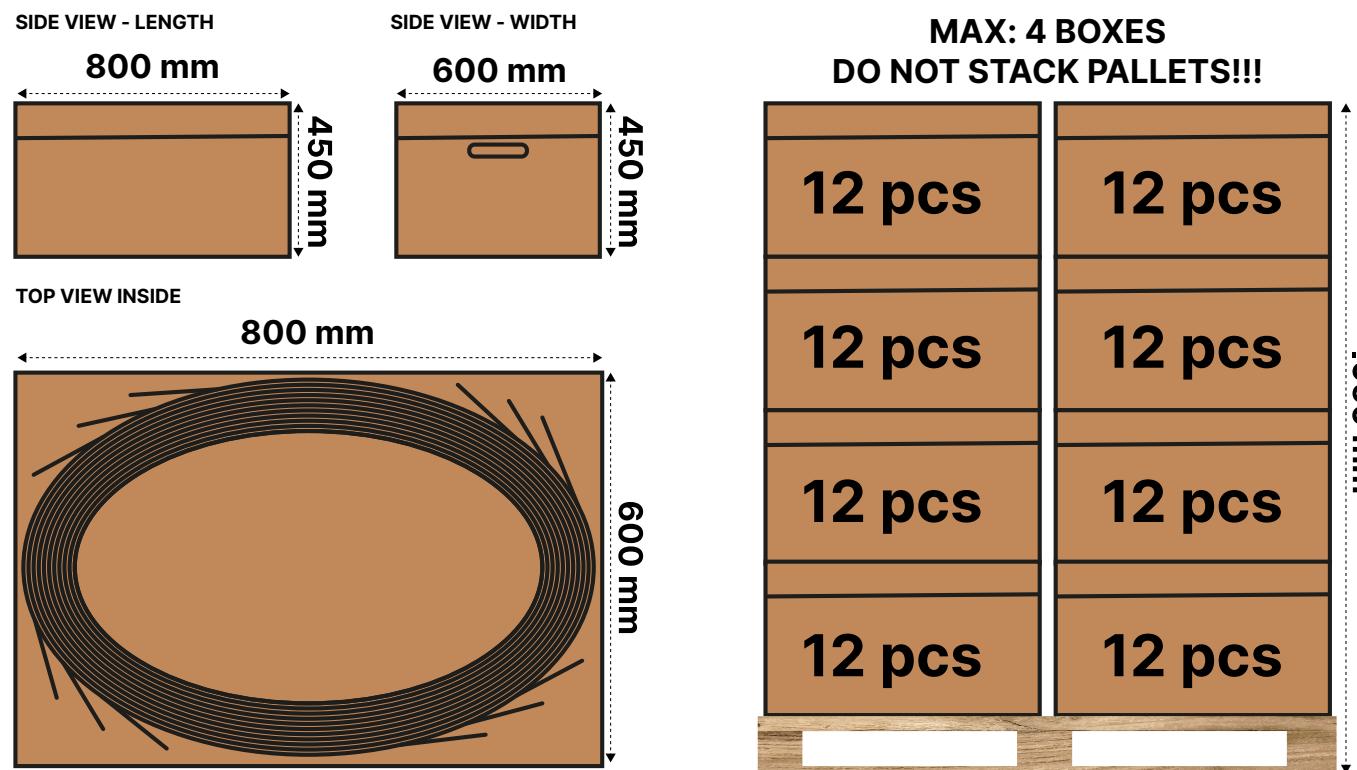
3 HANDLING AND STORAGE

The solar films are delivered as rolls in carton boxes. The packaging shall keep the solar films safe and prevent external exposure during the delivery.

3.1 PACKAGING

The dimension of each carton box is (LxWxH) 800 mm x 600 mm x 450 mm. One carton box contains 12 solar films. The solar films are rolled in one big circle with their junction boxes to the outside. The solar films are covered by a transparent frontside protection liner and an opaque liner on the backside.

It is possible to safely stack up a max. of 4 boxes on one wooden standard INKA-palette, stretched film is used to wrap the boxes on the palette. Do not stack pallets on top of each other.



3.2 HANDLING AND STORAGE

Unloading pallets from the truck should be done with a forklift. Check for damages of boxes carefully and claim if necessary, to the carrier.

Store them in a dry and ventilated warehouse-type facility, for protection from high temperatures and exposure to direct sunlight and moisture. The solar films should not be stored in areas with temperatures exceeding 25 °C. Keep the protective film wrapped around the shipment for better protection.

Transport the boxes close to the installation site and take out the solar films when everything is ready for installation. Lift and carry boxes with at least two persons.

Do not hold, carry, or lift solar films by the junction boxes or wires.

Unpack carefully, do not use sharp objects or tools (e.g. knives or scissors) to open the boxes. Take out only the solar films that are ready to be installed.

Separate packaging material (cardboard, liner films, roll straps) for recycling or disposal according to local regulations.

4 INSTALLATION & OPERATION

Only people who have read and understood the entire User Guide shall install, operate, maintain, or remove the solar films or systems.

4.1 SAFETY WARNINGS



HeliaSol 436-2000 generates above 55 V and 1.6 A when exposed to sunlight. Single solar films can create a shock hazard. Multiple interconnected solar films can create a lethal shock hazard during daylight hours, including periods of low light levels. The danger increases as solar films are connected together in series and/or parallel

To avoid damages, injury, fire, or any kind of malfunction, please comply with all the safety instructions throughout the User Guide and the following:

- Do not disconnect the solar films while under load.
- Do not disconnect the solar film connectors during daylight hours unless the solar film is in an open circuit condition.
- Solar films with damaged wires must be taken off the system immediately.
- Only apply the solar films in the specified areas of application described in section 4.2.

ATTENTION

Any kind of manipulation of the solar film will void the warranty and bears the risk of damage to property, health, and life!

In the event of fire, dry powder or CO₂ based fire-extinguishers should be used.

4.2 WHERE TO INSTALL

HeliaSol comes with an integrated backside adhesive (peel & stick) and can thus be installed on a wide range of materials:

- Glass
- Concrete, fiber cement
- Uncoated aluminum, stainless steel, copper
- Metal substrates coated with polyethylene (PE) or polyvinyl fluoride (PVF)
- Bitumen (after the application of a primer)
- Acrylic glass (polymethyl methacrylate, PMMA)

Heliatek tests intensively to ensure the long-term adhesion stability to many often-used materials from the construction industry. Heliatek can test other materials or surfaces and qualify them for the adhesion of HeliaSol upon request at support@heliatek.com. HeliaSol has a projected power production service life of 20 years. Please ensure that the mounting roof substrate has a remaining service life of at least 20 years. In addition, the substrate must be able to withstand the forces that occur during the installation of HeliaSol, and it must not crack or break during this process. HeliaSol is designed for up to 1000 V systems and can be installed at altitudes up to 2000 m per IEC 61730. HeliaSol is not suited to be installed on moving objects, such as vehicles.

The backside adhesive of HeliaSol is qualified for a firm, long-term adhesion. The mounting surface must be clean and dry - free from dirt, moisture, dust, oil, grease, adhesives, or other contamination, which can prevent or affect the firm adhesion of the solar film on the mounting surface. If the mounting surface is dirty, clean with material/surface specific cleaning products.

ATTENTION

Never apply paint, adhesives, or chemicals to the solar film.

Any application and fastening techniques other than using the adhesive film applied on the back require the express consent of Heliatek.

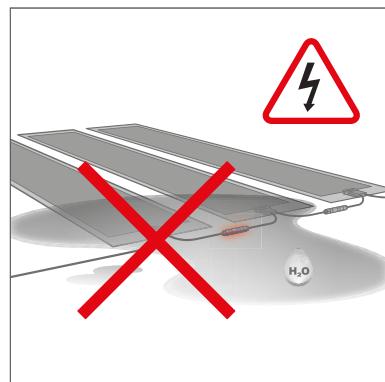
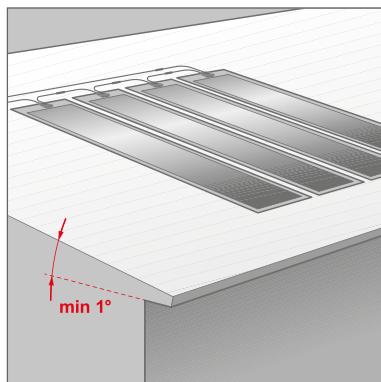
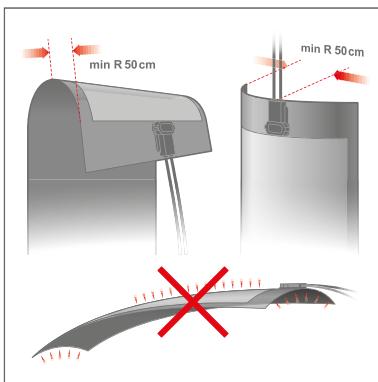
The mounting surface must be flat or bent on one axis and with a minimum bending radius of 50 cm. The substrate must always be solid and load-bearing, free of damage, corrosion, or degradation, and must be pre-treated for bonding in accordance with the installation instructions (section 4.4). In case of copper substrates, patina is not expected to affect the adhesion of HeliaSol on to the substrate.

ATTENTION

If HeliaSol is to be used on a flexible substrate, do not affix the solar film and then bend the substrate.

HeliaSol must always be installed on substrates with a fixed curvature, which is retained over the lifetime of the product/project.

The mounting surface on which HeliaSol is fixed must have an inclination of min. 1° and max. 90° (façade). Choose the location of the installation in accordance to avoid HeliaSol be immersed in water or exposed to water streams. HeliaSol is IP67 certified but it must be ensured that water (e.g. rainwater) can run off the solar film. The solar film direction must be selected so that rainwater or snowdrifts do not collect around the junction boxes.



The solar film must be attached to the substrate to a minimum 60% of its adhesive tape area, with the long edges being fixed to the substrate. Nevertheless, a full-surface adhesion of the solar film is recommended. If your solar project requires the bonding of HeliaSol with less than 60% of its rear area, please contact Heliatek for further support at support@heliatek.com. The module must not be deformed or glued under tension by raised beads in the sheet metal or over sharp edges such as nails or screws, under no circumstances. Do not install HeliaSol above expansion gaps. In the case of single-ply membrane roofs, install HeliaSol at a 2 mm distance from the seam edge welds.

ATTENTION

The concentration of sunlight on the solar film surface by mirrors or other means is not permitted. It must be ensured that parts of the building or technical installations in the vicinity do not have such a side effect on the solar film.

A covering of the inactive edge is permissible, as long as it is ensured that the edge cells are not partially or completely covered in a longitudinal direction and no significant shading of individual cells is caused by the shape and height of the cells. The cover must not cause mechanical damage, dents, scratches, or pressure on the solar film. In addition, the cover must be in a shape that water does not collect on the solar film surface.

Using HeliaSol in combination with primers

Sandy substrates (e.g. old plaster façades) or surfaces with paint flaking or corrosion are not suitable for installation. For specific materials with a rough surface, such as concrete and bitumen, the application of a primer is required prior to the adhesion of HeliaSol (See Appendix 2).

Below you can find recommended primers and their application procedures for installing HeliaSol on bitumen and concrete substrates. For more information or support, please contact Heliatek at support@heliatek.com.

Substrate Type	Concrete	
Primer	Tesa 60153	3M Primer94
Type	Liquid	
Preparation	Ready to use	
Application	Apply primer with a brush	
Drying Time	1-5 mins (depending on ambient conditions)	
Quantity	50-100 ml/m ² (depending on surface roughness and porosity)	

Substrate Type	Bitumen	
Primer	Bostik R341	MasterSeal FX6100
Type	Bitumen -based	Concrete - based
Preparation	Ready to use	Mix with water (2.5:1)
Substrate Pre-treatment	Apply a new and dry layer of bituminous coating	
Application	Apply primer with a brush	
Smoothening	Brush with water after ~1h	
Drying Time	24h (sunny day) / 48h (cloudy weather, no rain)	
Quantity	0.7 kg/m ²	0.8-1 kg/m ²

If concrete is already covered with paint, this may serve as a primer already. In this case, please check the feasibility with the test kit (see Appendix 3).

The right choice of the Bitumen primer strongly depends on the specific Bitumen type used. We recommend preparing a small test area with the primer of your choice according to the table above, followed by application of our adhesion test kit (See Appendix 3). For more information and to obtain our test kit, please contact Heliatek at support@heliatek.com.

Installing HeliaSol on membranes

Heliatek has tested the adhesion of HeliaSol on various membrane types such as:

- PVC (polyvinyl chloride)
- TPO (thermoplastic polyolefins)
- FPO (flexible polyolefine)
- EPDM (ethylene propylene diene rubber)
- ETFE (ethylene-tetrafluoroethylene copolymer)

Based on these tests, adhesion of HeliaSol will not work on ETFE-based substrates, due to the intrinsic self-cleaning and soil-repelling properties of ETFE.

For all other membrane types, long-term adhesion of HeliaSol on these membrane substrates is strongly dependent on the condition and type of the membrane, especially their surface treatment. Many kinds of variants exist which makes it impossible to give a clear list of qualified materials. However, a few general recommendations can be given:

- For freshly installed membranes, degassing of softeners contained in the membrane materials typically react with the film's adhesive tape and affect its adhesion, so long-term adhesion cannot be guaranteed. Use the adhesion test kit (see below) to check for sufficient initial adhesion to HeliaSol. If successful, contact Heliatek at support@heliatek.com to discuss long-term tests.
- Adhesion on membranes which have been exposed to the outdoor weather conditions for more than 2 years is expected to work without problems. For example, a TPO membrane roof which has been installed more than 2 years ago typically yields sufficient adhesion to HeliaSol as the softeners have been outgassed over time. Use the adhesion test kit (see below) to check for sufficient initial adhesion to HeliaSol and proceed with the project if test was successful.
- For any membrane substrate, use our Heliatek adhesion test kit to check the compatibility of HeliaSol adhesive tape with the targeted substrate. The procedure is described in Appendix 3 of the user guide and should be applied before planning / installing the solar project. Kits are provided by Heliatek, please contact support@heliatek.com.

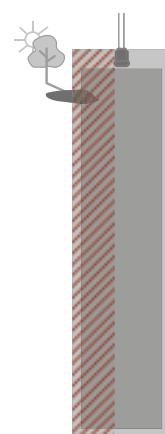
4.3 SHADING CONSIDERATIONS

Specific shading patterns can cause reverse-bias conditions in the solar film which may affect its performance and in extreme cases it can cause local burns on the solar film surface. To avoid this, and during the project lifetime, the following information must be taken into consideration when selecting the installation location, inclination, and orientation regarding shading:

- Shading parallel to the solar cells (longitudinal stripes) in the solar film can lead to permanent power loss of the associated string during operation and cause serious damage to the solar film.
- Stable objects at close range (up to 10 m) whose shadows run along with the solar cells in parallel (parallel shading) must be avoided.
- Mobile objects at close range (up to 10 m), such as persons, vehicles, or cleaning equipment must be avoided.
- Diffuse shading from objects in a distance greater than 10 m carries only a low risk of damage but should be avoided.
- Partial shading of solar films in a series connection can lead to permanent damage to the solar film.
- There is no risk due to shading while the solar film is at open-circuit condition.

ATTENTION

Parallel shading
must be avoided



ATTENTION

Do not place objects on the solar film, e.g. tools, cleaning equipment.

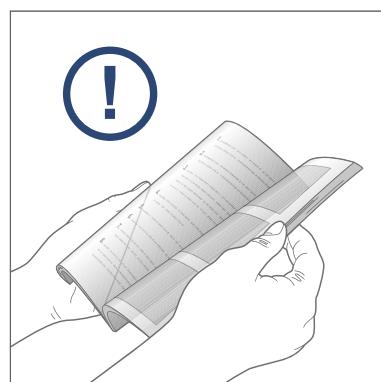
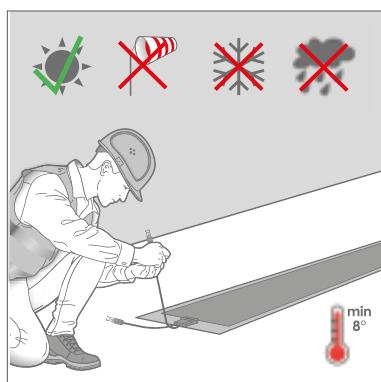
Beads or profiles located to the side of HeliaSol can lead to the parallel shading of solar film, and this must be avoided.

4.4 HOW TO INSTALL

Everyone involved in the installation must be informed about the safety instructions before unpacking, transporting, and installing the solar film. Select your personal protective equipment based on work consistent with local and/or national standards. The solar film shall be installed in a non-wired state. Only install new and undamaged solar films.

To minimize the possibility of accidental risk of damages, health & life and for a safe installation of HeliaSol please make sure that the following conditions of the installation area are present:

1. Weather – dry, no rain, no snowing, no strong wind, and substrate temperatures above 8 °C. Solar films and tools should not be exposed to moisture or rain at any time during the installation.
2. Always wear insulating gloves and safety shoes (with rubber soles) when working with solar films or system components. Select your personal protective equipment based on work consistent with local and/or national standards. Secure the work area against access by uninvolved persons before starting work. Use only dry insulated tools.
3. The following tools are recommended for the installation of HeliaSol:
 - Marker
 - Yardstick/Ruler
 - Two rollers for lamination: one with a length that is higher than the width of the solar film (at least 45 cm), and a small one of up to 10 cm.

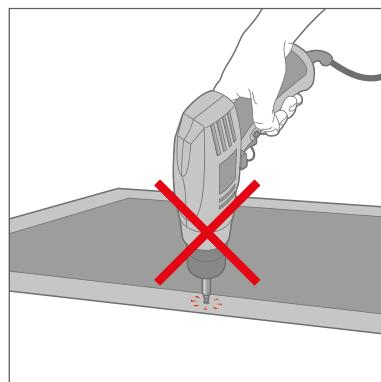
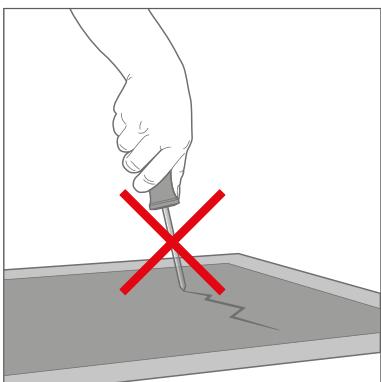


ATTENTION

Do not use any sharp tools and do not place the solar films face-down in direct contact with abrasive surfaces. Danger to scratch the solar film surface.

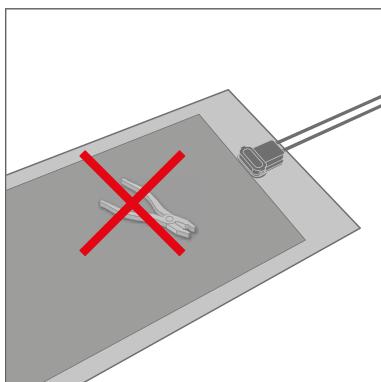
Avoid stepping or walking on the solar film. Danger to scratch the solar film surface.

Do not cut, penetrate, or mechanically process/modify the solar film.



Do not leave objects (such as tools, etc.) on the solar film.

Handle the solar film with care, and do not expose it to mechanical stress. Do not hold, carry, or lift solar film by the junction boxes or cables.

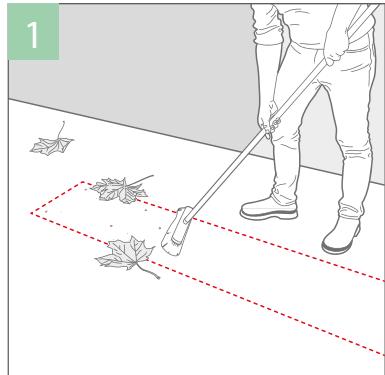


Do not short-circuit the solar films by connecting its connectors to each other.

INSTALLATION OF HELIASOL ON A FLAT OR SLIGHTLY TILTED ROOF

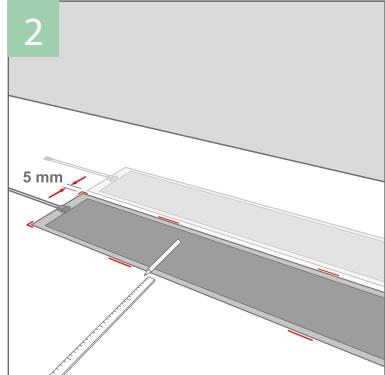
1. Prepare the mounting surface for the installation of HeliaSol.

Ensure that the mounting surface is clean and dry - free from dirt, moisture, dust, oil, grease, adhesives, or other contamination, which can prevent or affect the firm adhesion of the solar film on the mounting surface. If the mounting surface is dirty, clean with material/surface specific cleaning products.



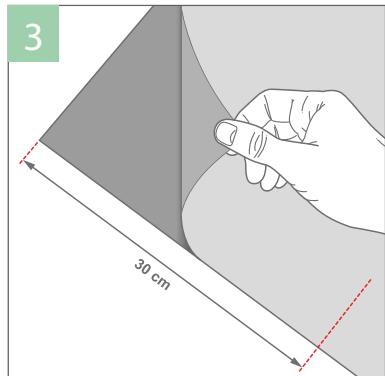
2. Place the solar film for an alignment test on the position to be installed.

Align the solar film and use a marker to mark the position of the corners and sides of the solar film. Ensure that the solar films are aligned parallel to each other to avoid an overlap of the modules. We recommend leaving a distance of at least 5 mm between the modules to compensate for slight tilts after fixing of the first part of the module (see point 4 below). Do not remove the protective liners yet.



3. Remove the backside protection liner and check solar film alignment

Start from the solar film edge opposite to the junction box. Peel off the backside protection liner for about 30 cm (12 inches), starting from one corner. Check solar film alignment according to your marks. Place the solar film with the revealed adhesive area towards the mounting surface.



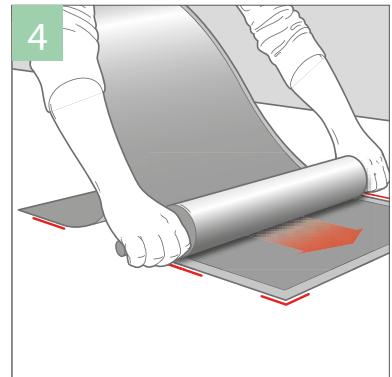
Ensure that the solar film is aligned with the marks and slightly press the solar film edges with your hand towards the mounting surface, to fix it at the correct position.

ATTENTION

Once the solar film is fixed on the mounting substrate, any position correction is not possible without damaging the solar film.

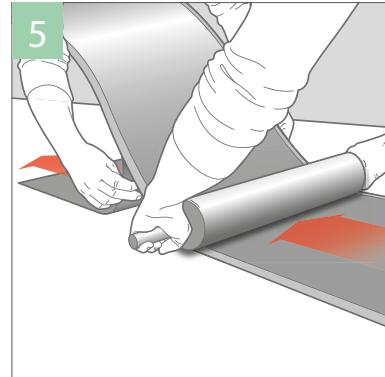
4. Fix HeliaSol on the mounting surface, starting from the side opposite to the junction box.

Use a silicone roller to fix the revealed adhesive area (approximately 30 cm or 12 inches) of the solar film on the substrate, working from the middle of the film towards the edges, to ensure that there is no air trapped under the solar film.



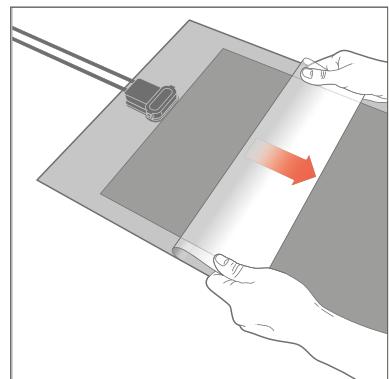
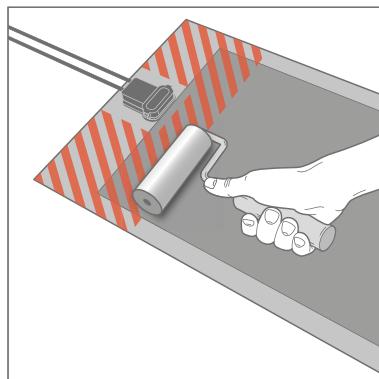
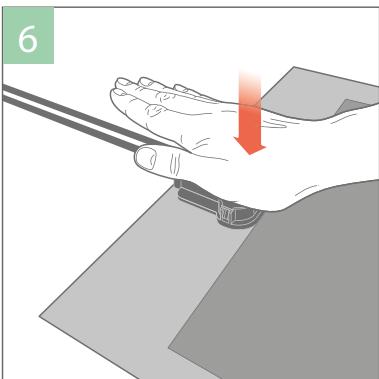
5. Remove the backside protection liner carefully and work towards the junction box.

Remove the backside protection liner for another 20 cm (8 inches). Use a silicone roller to fix this part of the solar film on the substrate. Make sure the solar film is evenly fixed on the surface by moving the silicon roller over the entire solar film width, and that the silicon roller always gives the first contact of the solar film to the surface. Work towards the junction box. Repeat step 5 until the solar film area around the junction box is reached.



6. Fix the junction box and the remaining solar film area on the mounting surface. Remove the frontside protection liner.

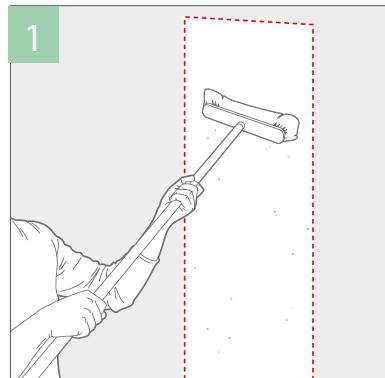
Press firmly the junction box with your hand to fix it on the mounting surface. Use the small silicon roller to fix the remaining solar film area around the junction box, starting from the solar film area that is adhered to and working towards the edges to avoid any air trapped under the solar film. Remove the frontside protection liner. Your HeliaSol is ready for use.



INSTALLATION OF HELIASOL ON FAÇADE OR STEEP ROOF

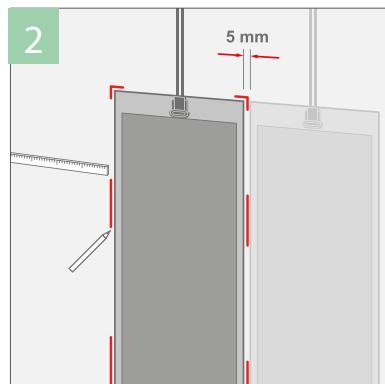
1. Prepare the mounting surface for the installation of HeliaSol.

Ensure that the mounting surface is clean and dry - free from dirt, moisture, dust, oil, grease, adhesives, or other contamination, which can prevent or affect the firm adhesion of the solar film on the mounting surface. If the mounting surface is dirty, clean with material/surface specific cleaning products.



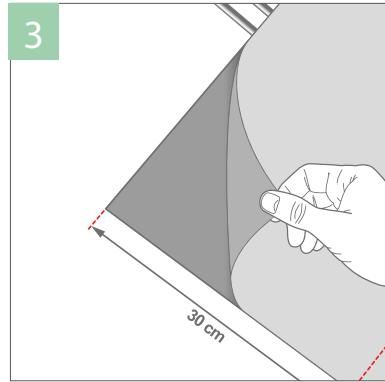
2. Place the solar film for an alignment test on the position to be installed.

Align the solar film and use a marker to mark the position of the corners and sides of the solar film. Multiple solar films should be parallel to each other, with a 5 mm distance between their edges. Do not remove the protective liners yet.



3. Remove the backside protection liner and check solar film alignment

Start from the solar film edge hosting the junction box. Peel off the backside protection liner for about 30 cm (12 inches), starting from one corner.

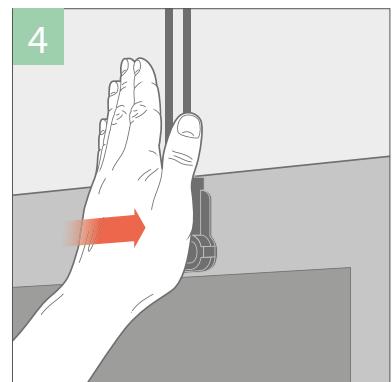
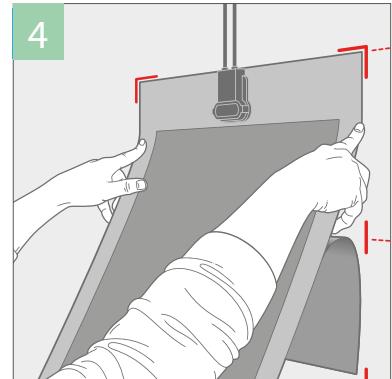


4. Place and align HeliaSol on the mounting surface. Fix the edges and the junction box.

Place the solar film on the mounting surface with the revealed adhesive area oriented towards the mounting surface. Both horizontal and vertical arrangement are allowed and you can either have the junction box oriented upwards or downwards.

Ensure that the solar film is aligned with the marks and slightly press the solar film edges with your hand towards the mounting surface, to fix it at the correct position.

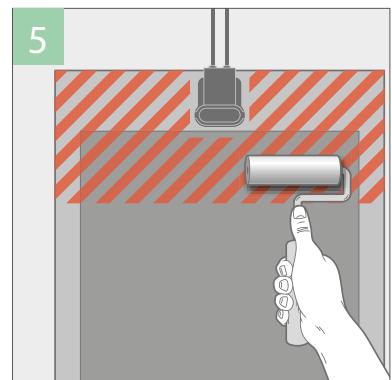
In case of junction box oriented upwards, press firmly the junction box with your hand to fix it on the mounting surface.



5. Fix the edge of HeliaSol on the mounting surface.

Use a small silicone roller to fix the revealed adhesive area (approximately 30 cm or 12 inches) of the solar film on the substrate.

Work from the middle of the film towards the edges, to ensure that there is no air trapped under the solar film.

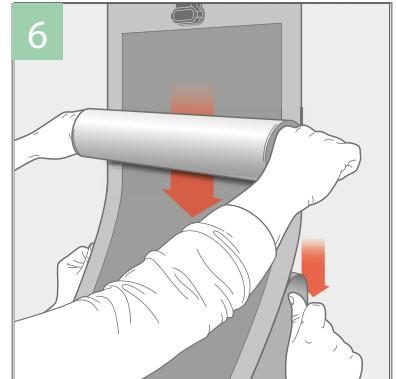


ATTENTION

If during the installation you notice that a solar film is misaligned compared to the desired position, do not try to correct its position. Once the solar film is fixed on the mounting substrate, any position correction is not possible without damaging the solar film.

6. Remove the backside protection liner carefully and fix the solar film on the mounting surface.

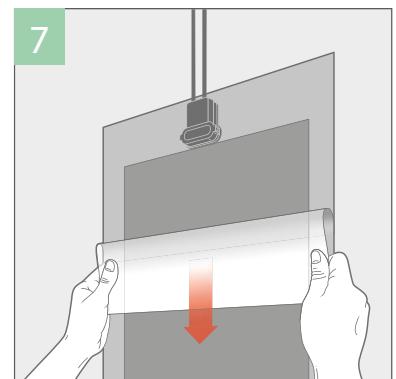
Carefully remove the backside protection liner for another 20 cm (8 inches). Starting from the fixed edge, use a silicone roller to fix the rest of the solar film on the substrate. A second person can take care to keep the exposed part of the adhesive tape away from the mounting surface.



Repeat step 6 until the solar film is fixed entirely. Make sure that the silicon roller always gives the first contact of the solar film to the surface. Make sure the solar film is evenly fixed on the surface by moving the silicon roller over the entire width.

7. Remove the frontside protection liner

Your HeliaSol is ready for use.



Electrical Installation - General Information

HeliaSol is defined and manufactured with protection class II according to IEC 61140 and a maximum system voltage of 1000 VDC. All electrical components that are interconnected to the solar films must match these conditions.

4.5 WIRE MANAGEMENT

All wire management must comply with the applicable local requirements (i.e. IEC codes and standards) for maintaining and managing wires. HeliaSol is equipped with a Tyco Electronics TE Solarlok Micro junction box which must only be connected with Tyco Electronics TE PV4-S connectors. The junction box contains bypass diodes. If the solar films are connected incorrectly, damage can be done to the diodes. Pairing with connectors of other manufacturers is not permitted, even if the other manufacturer assures compatibility.

For use in solar systems suitable cables with a conductor cross-section of 2.5 mm² to 4 mm² must be used as connecting cables, which correspond to the ambient conditions, the current rating, and the system voltage range of given solar films. The permissible conductor cross-sections and cable outer diameter ranges of the connector type as well as the installation instructions of the connector manufacturer must be observed.

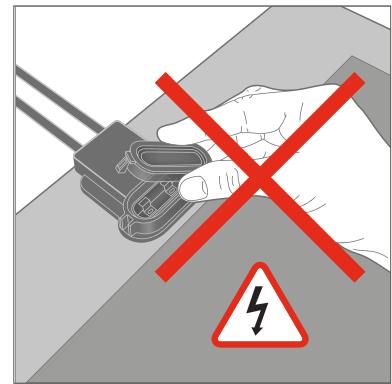
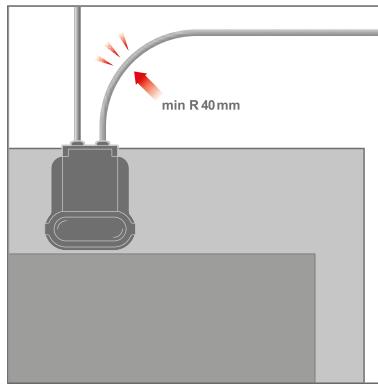
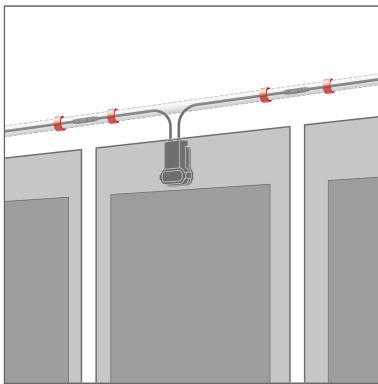
ATTENTION

Ensure connectors are fully locked and mated. Do not loosen, alter, or modify the factory-installed connectors on the junction box. Do not attempt to open or remove the junction box from the solar film.

Ensure that the connectors remain clean and dry until the connection is closed. The use of dust caps is recommended if the connectors are to remain open.

Contamination can cause fires. Ensure that the connectors are protected from dirt and moisture during the time between transport to the installation site and the electrical connection.

When laying the connecting cables, a minimum bending radius of 40 mm must be observed and permanently secured with suitable cable fixings. The cable routing must be secured by strain reliefs in such a way that no mechanical stresses or other stresses are exerted by the cable on the junction boxes or the solar film. The cables must be fixed mechanically between the junction box and the nearest bend of the cable on the substrate, cable duct, or other construction elements with sufficient stability. Do not open the junction box.



All cables must be routed and fastened in cable ducts, cable protection conduits, or according to local regulations in such a way that they:

- Do not pose a trip hazard.
- Are well protected against accidental or deliberate damage.
- Are effectively protected against animal bites, insofar as this danger is to be expected at the installation site.
- Are protected against direct sunlight.
- Are protected against standing water.

4.6 ELECTRICAL INTERCONNECTION

HeliaSol can be connected in parallel to increase the system current and/or in series to increase the system voltage. Pairing with connectors of other manufacturers is not permitted, even if the other manufacturer assures compatibility.

ATTENTION

Do not short-circuit the solar films by connecting its connectors to each other.

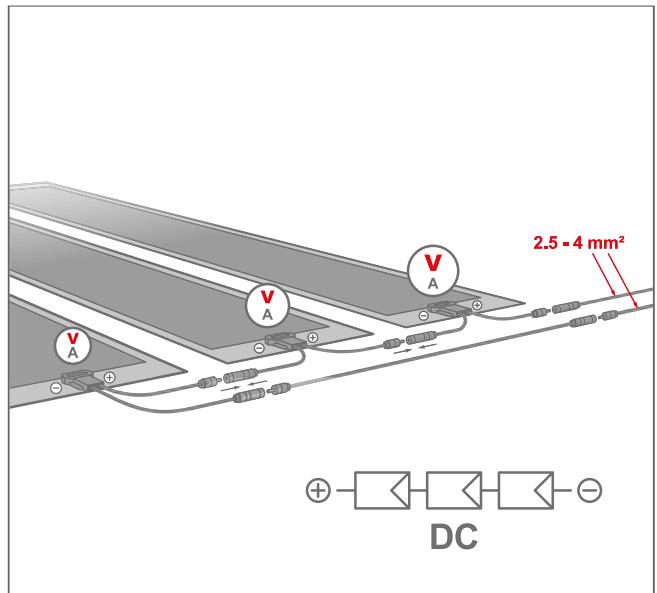
System derating factors

Under normal conditions, a photovoltaic module is likely to experience conditions that produce higher current and/or voltage than reported at standard test conditions. Accordingly, the values of I_{SC} and V_{OC} marked on a PV module should be multiplied by a factor of 1.25 when determining component voltage ratings, conductor current ratings, and size of controls (e.g. inverter) connected to the PV output. The safety factor of 1.25 for the minimum voltage rating of the components can be modified during the design of a system according to the minimum temperature of the location of the installation and the temperature coefficient for V_{OC} . I_{SC} can be adjusted based on maximal temperature, irradiance, and orientation of the module. To this end, a full simulation for the specific location is recommended using long term weather data.

Series connection

To connect solar films in series, connect the cables from the negative connector of the first solar film to the positive connector of the second solar film, and so on.

When designing a system with multiple solar films connected in series, make sure that the maximum permissible system voltage specified on the nameplate or in the datasheet is not exceeded, taking into account all possible operating conditions, including the temperature coefficient, and the minimum ambient temperature.



Taking into account the 1.25 safety factor, the maximum number of modules n that can be connected in series within the specified maximum system voltage V_{sys} can be calculated as:

$$n = V_{sys} / (1.25 \cdot V_{oc})$$

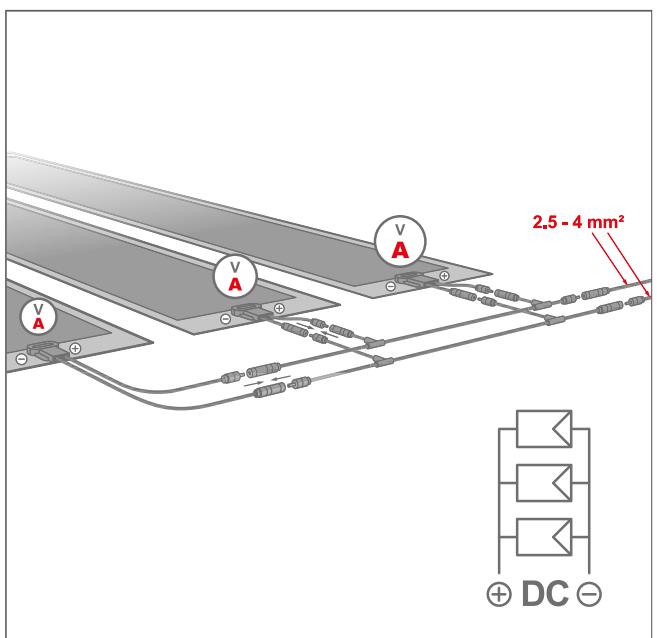
Example

For HeliaSol 436-2000-55 ($V_{oc} = 56.1V$, $V_{sys} = 1000V$), the maximum number n of modules connected in series equals to:

$$n = 1000V / (1.25 \cdot 56.1V) = 14 \text{ modules}$$

Parallel connection

The low string current of HeliaSol® makes it possible to connect multiple strings together in parallel and return a single pair of DC cables to the combiner box or string inverter. Parallel strings should have similar voltages, which is achieved by installing an equal number of solar films of the same type. Reverse currents can lead to solar film failure, which can lead to fire, open electricity, or similar hazards. Thus, it is important to not exceed the maximum reverse current, stated in the nameplate or the datasheet. Situations with reverse current can be avoided with a proper system design and/or the use of reverse current blocking diodes or fuses.



Furthermore, for the layout of the connection cables, the total currents must be taken into account, taking into consideration the maximum ambient temperature and the short circuit current I_{sc} including its temperature coefficient, and/or a safety factor of 1.25.

Taking into account the 1.25 safety factor, the maximum number of strings n that can be connected in parallel within the specified maximum overcurrent protection rating OCR and without additional safety measures (i.e. fuses or blocking diodes) can be calculated as:

$$n < \text{OCR} / (1.25 \cdot I_{sc}) + 1$$

Example

For HeliaSol 436-2000-55 ($I_{sc} = 1.63\text{A}$, $\text{OCR} = 2.7\text{A}$), the maximum number n of strings connected in parallel can be estimated as:

$$n < 2.7\text{A} / (1.25 \cdot 1.63\text{A}) + 1 = 2.32$$

→ $n = 2$ strings in parallel (without using blocking diodes)

4.7 INVERTER COMPATIBILITY

For installation on non-grounded substrates (e.g. membranes, concrete, bitumen), a wide range of string, central, transformer and transformerless inverters can be used with HeliaSol, ensuring that the inverter's extreme (minimum/maximum) parameters are not exceeded.

For installation on grounded conductive substrates (e.g. metal), Heliatek recommends the use of inverters with transformers and galvanic isolation or three-phase inverters. If available, the use of inverters with H5 or HERIC topology is beneficial. The maximum coupling capacity of the inverter must be taken from the operating instructions of the inverter. For HeliaSol, a dry state parasitic capacitance of 15nF/m^2 must be assumed in connection with a conductive substrate under unfavorable conditions.

Example

If Coupling Capacitance for one inverter is $X \mu\text{F}$ then the number n of HeliaSol 436-2000-55 modules that can be installed with this inverter should be less than:

$$n < X \cdot 1000 / (15 \cdot 0.872)$$

It should be taken into account when designing the system, deciding the inverter type (with transformer or transformerless), and/or the installation substrate. Heliatek has prior experience and recommends the use of inverters from the following brands: SMA, SolarEdge, Fronius, AEConversion, Huawei, Kaco, Kostal.

In more detail with regard to the inverter type:

1. Transformerless inverters:

Transformerless inverters are currently one of the most common solution for scalable solar system, however, its smaller size and weight comes with no galvanic isolation to the AC-DC side.

This has the following implications:

- Almost all 1-phase transformerless inverters pass half the grid amplitude to the PV field.
- With 3-phase transformerless inverters, the amplitude of the oscillations is usually significantly lower.
- The voltage fluctuations transferred can lead to leakage currents and changed behavior with regard to residual current monitoring. If this is not accounted for in the system design, the system's inverter can be in shutdown due to this issue.

2. Inverter with a transformer:

Due to the galvanic isolation, the voltage in the PV generator only oscillates by „a few volts“ here, i.e. much smaller than for transformerless inverters. However, the implications are still the same: in the case of a too large built-up capacitance, a leakage current measurement generates a faulty value which results in a temporary shutdown of the inverter. To avoid this temporary loss of yield, the system wiring must be designed according to the capacitive maximum value of the inverter. Inverters with a transformer usually allow to design systems with significantly larger capacitive value than for transformerless inverters.

4.8 EARTHING / EQUIPOTENTIAL BONDING

HeliaSol solar films do not have metallic frame or external metallic parts and, therefore, do not require earthing or equipotential bonding. Connection boxes and metal conduits should be connected to the ground as lightning protection, in accordance with local, regional, and national standards and regulations. Refer to your local authority for any code requirements that may be required in the installation jurisdiction.



4.9 FIRE RATINGS AND RESISTANCE TO EXTERNAL FIRE

Be sure to be compliant with all relevant local and national laws, regulations, and codes related fire resistance before installing the solar films. The solar films are tested and rated according to the following standards, in combination with metal, concrete or polymeric waterproofing sheet with Fire class E acc. EN 13501-1 or higher:

- EN13501-01 Class E (resistance to other external fire sources not evaluated).

All tests have been performed at the Fire Laboratory of MPA Dresden GmbH

5 MAINTENANCE

To ensure a safe and effective operation of the installation, the solar films must be carefully and properly inspected, cleaned, and maintained within regular intervals or after special conditions have been met (e.g. extreme weather conditions).

ATTENTION

All activity relating to inspection, cleaning, and maintenance work must only be carried out while the system is switched off (open-circuit condition) and at low irradiation levels.

If the calculated yield is not met by the measured numbers you may start by troubleshooting the most common causes: inverter issues, miscalibrated or malfunctioning monitoring devices, wrong wiring or electrical connection, shading or partial shading, dirt, and soiling on the solar film surface, snow or other substances/materials covering the solar film.

HeliaSol is a one-piece product whose parts cannot be replaced individually. If the inspection results in detecting that one part of the solar film is damaged or defective, the whole solar film must be safely taken off the system and be replaced. All additional parts to the solar film to integrate it into the system are subject to the regulations and maintenance requirements of the respective manufacturer.

5.1 SYSTEM INSPECTION

For all installations, a regular (visual) inspection for damages or unwanted changes, which may result in the damage of the solar films, is required at least every 12 months.

Additionally, the system must be checked:

- If the inverter displays error messages indicating solar film faults or if the performance of the system appears to be declining considerably.
- After extreme weather events (sandstorm, heavy hail, heavy rain, flooding, etc.)
- If there is suspicion that unauthorized persons have had access to the installation.

Every inspection should be logged to record all changes.

How to inspect the solar films:

1. Power off the system, secure it from accidental switch on, and check the system of any residual electricity.
2. Please check for:
 - Secure hold of all system components
 - Safe connection, clean and undamaged electrical components
 - No standing waters around the junction box
 - Visual inspection for delamination, defects, or such kind.
3. Keep the solar film clean and free from debris. For more info about cleaning, please read the respective section.
4. In case of snow, ensure that the solar film surface pressure is at or below the design load by removing snow.

ATTENTION

Always power off the system before performing maintenance.



If there is any doubt about the condition of the solar films, the relevant parts should be documented by photos and, together with information on the serial number and wiring, sent to Heliatek at support@heliatek.com. The serial number can be found on the nameplate or imprinted at the end of the solar film, opposite to the junction box. The system or the affected areas must then be secured immediately so that they are only accessible to the maintenance personnel. The further procedure must be clarified with Heliatek.

5.2 CLEANING

The solar films are equipped with a front sheet that allows ordinary dust or dirt to be washed away by normal rainfall, best achieved when the modules are installed at an inclination angle of 25 degrees or more from the horizontal plane.

If cleaning is performed to maximize system performance and ensure long-term performance, please ensure that the system is powered off, secured from accidental switch on, and check the system of any residual electricity.

Clean each solar film with care by using deionized water and a lint free cloth. Let the water clean the surface at first, and with the wet cloth clean the area that is still not clean. Do not use excessive pressure, since it might damage the solar film permanently. If there are stains such as bird droppings, you can use isopropanol or ethanol or water to clean the surface. Any kind of surface pollution may result in a non-uniform loading, which can lead potentially to the formation of hotspots or reduction of the power output, which may damage the solar film permanently or affect the long-term performance.

ATTENTION

Start early in the morning or late in the night when solar irradiation is the lowest.

Partial direct shading during cleaning can cause permanent damage to solar cells due to reverse-bias conditions, even in low light conditions, if the system is not powered off.

Do not step on the solar film while cleaning them, shoes could have sharp or hard particles on the heels and can scratch or penetrate the modules.

Do not use high-pressure water jets.

Do not use abrasive cleaners or cleaning solutions containing acids such as hydrochloric acid, D-Limonene, ammonia, or sodium hydroxide.

Do not use water near the junction box.

6 REMOVAL AND DISPOSAL

Solar films that are not suited for safe operation (e.g. damaged or defective) or no longer meet the goals or targets must be safely removed from the system and shall be disposed in accordance with the local regulations for recycling and disposal.

6.1 HOW TO REMOVE

The backside adhesive of HeliaSol ensures a firm and permanent adhesion on the applied surface. Please note that the removal destroys the solar film permanently.

To safely separate the solar film from the surface without unnecessary risk:

1. Power off the system, secure it from accidental switch on and check the system of any residual electricity.
2. Identify the solar film to be removed and mark it.
3. Disconnect all cables from the solar film.
4. To remove the backside adhesive from the underground, preferably use a heat gun to warm up the adhesive layer up to 100 °C.
5. Remove the film slowly and completely. Pull the films in a flat angle.
6. If any adhesive residues are left on the surface, a petroleum ether-based adhesive remover can be used (e.g, Tesa-60042). To moisten the residues, apply the remover and wait at least 2 minutes before removing the remaining material with a scraper or similar. The use of the remover can be repeated in case residues are remaining on the applied surface. Use

a towel and isopropanol for the final cleaning. On porous or other rough surfaces (e.g. concrete wall) a pressure washer instead of the use of solvents can be considered.

Please note that when a solar film is removed, optical dissimilarities may occur between the surface area that was covered by the solar film and the uncovered surface area around it, since HeliSol protects the underlying substrate from weather exposure. In the case of coated metal substrates, a new coating may be necessary after complete removal of the films.

6.2 DISPOSAL

The solar films do not consist of any components (e.g. toxic materials) that need special attention during the process of disposal. They can be handled like any other electronic waste and must be brought to the local recycling and disposal center or any other facility that oversees recycling and disposal, according to the local regulations for recycling or disposal.

ATTENTION

Do not dispose the solar film in normal household waste.



For further information, please contact your local recycle and disposal center or us at:
sayhello@heliatek.com.

APPENDIX 1: INSTALLATION CHECKLIST FOR HELIASOL

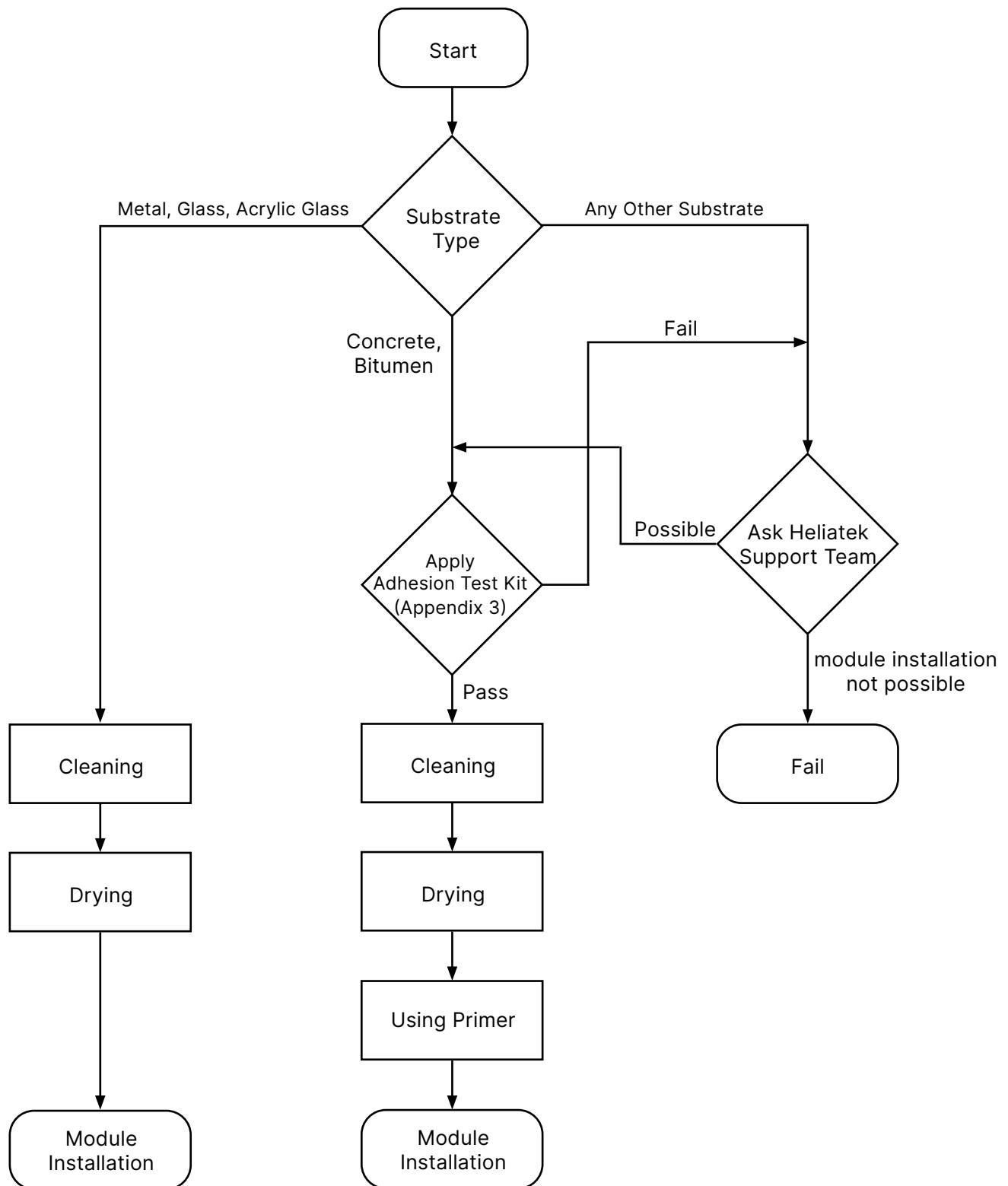
PLEASE NOTE

This checklist complements the product's User Guide but does not replace it: Always refer to the User Guide for a proper and safe installation of HeliaSol.

Before Installation		
<input type="checkbox"/>	1.1.	Receiving and Storing (Ref: §3.2 of the User Guide) <ul style="list-style-type: none">o Boxes are not damagedo Storing in a ventilated warehouse with dry air. Must avoid temperatures more than 25°Co Keep the protective film wrapped around the shipment for protection.
<input type="checkbox"/>	1.2.	Project Design (Ref: §4.6 and §4.7 of the User Guide) <ul style="list-style-type: none">o Max system voltage & electrical limitations according to datasheeto Parasitic capacitance for grounded (metal) substrateso System design, inverter & other components selection, etc., project plans createdo System simulation
<input type="checkbox"/>	1.3.	On-Site Checks (Ref: §4.2 and §4.3 of the User Guide) <ul style="list-style-type: none">o Substrate checks with flowchart, see Appendix 2o Module inclination >1°o Min radius of uni-axially module bending: R >50cmo Avoid standing water situations where modules are to be installedo Avoid critical shading situation
<input type="checkbox"/>	1.4.	Final Preparation <ul style="list-style-type: none">o Receive Heliatek installer kito Provide proper connectors (connector type according to datasheet and sufficient number of connectors for installation)o Provide primer (if needed)o All installers have received training by Heliateko Receive project plano Appoint the responsible people for the installation dayo Installation day weather check (temperature, wind speed, precipitation)

Installation Process (Ref: §4.4 of the User Manual)		
<input type="checkbox"/>	2.1.	<p>Substrate and Weather Condition</p> <ul style="list-style-type: none"> o Clean the substrate (free from dirt, moisture, dust, oil, grease, adhesive, moss, paint flaking, corrosion, or any other particle) o Let the substrate dry o Weather final check for gluing the module (rain, snow, or strong wind) o Substrate temperature should be more than 8°C o Marking and determining the positions of the modules
<input type="checkbox"/>	2.2.	<p>Following local HSE safety codes</p> <ul style="list-style-type: none"> o insulating gloves o safety shoes o Helmet o Mask (if necessary) o Unauthorized persons have no access to the work area
<input type="checkbox"/>	2.3.	<p>Installation</p> <ul style="list-style-type: none"> o Following module alignment and position from project plan design documents o Primer application (if needed) according to instructions user guide o Install modules according to training received and instructions in user guide o Never short-circuit HeliaSol modules
<input type="checkbox"/>	2.4.	<p>Final Actions</p> <ul style="list-style-type: none"> o Remove front side protection liner of all modules o Collect waste & recycle o Functional test
After Installation		
<input type="checkbox"/>	3.1.	As Built Documentation
<input type="checkbox"/>	3.2.	<p>Installation Signs</p> <ul style="list-style-type: none"> o Do not step on the modules o Electrical safety warnings o Zone numbering based on the final design
<input type="checkbox"/>	3.3.	Following System Inspection Methods (Ref: §5.1 of the User Guide)
<input type="checkbox"/>	3.4.	Following Module Cleaning Methods (Ref: §5.2 of the User Guide)

APPENDIX 2: FLOWCHART FOR SELECTING ADHESION METHOD BASED ON SUBSTRATE



APPENDIX 3:

HELIASOL ONSITE ADHESION TEST

DISCLAIMER

- The adhesion of the HeliaSol BSA (backside adhesive) may be affected by a specific material type (e.g., different types of a PVC or TPO membrane), or the condition (ageing) of the targeted material.
- Although various substrate materials undergo extensive testing in Heliatek, an easy test will be needed as a quick check of sufficient adhesion of our BSA to the targeted substrate.
- This onsite adhesion test does not replace the standard substrate qualification but works complementary to it.
- The test is considered successful if the adhesive tape is fully split to the substrate and the sample.

TEST PROCEDURE

1) Clean the substrate:

Substrate should be free from dirt, moisture, dust, paint flakes, oil, grease, adhesives, or other contamination.

2) Stick the sample to the substrate:

Use primer if needed according to instructions. Remove the backside adhesive protection liner and stick the sample on the substrate. Press firmly to ensure that the sample is fixed.

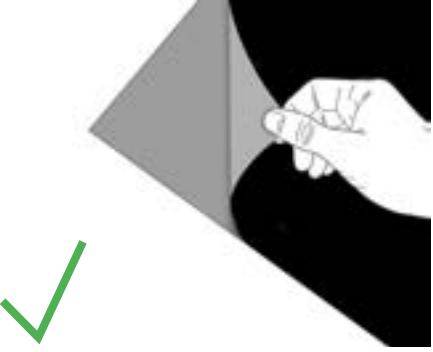
3) Remove the sample after 72 hours:

Remove mechanically the samples after 72 hours from its application. Pull the sample off in perpendicular direction to the substrate either by hand or with tools if necessary.

4) Take pictures and inform Heliatek:

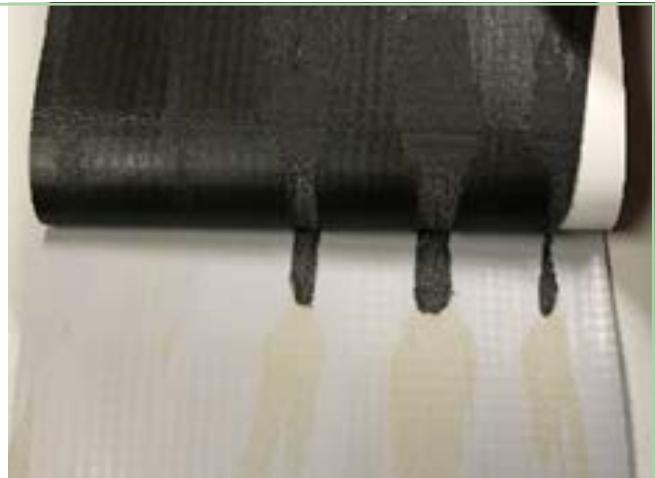
After removing the sample, take pictures of the substrate and the sample, and forward them to Heliatek for evaluation together with the following "Installation Site Evaluation Form"

Positive Test Result	Negative Test Result
After removing the samples, the adhesive still sticks to the substrate. The foam tape is split.	After removing the samples, the adhesive does not or only to a minor degree stick to the substrate.






Samples of Positive Test Results



Samples of Negative Test Results

Removing adhesive residues from the test surface

If any adhesive residues are left on the surface, a commercially available petroleum ether-based adhesive remover can be used. To moisten the residues, apply the remover and wait at least 2 minutes before removing the remaining material with a scraper or similar. The use of the remover can be repeated in case residues remain on the applied surface. Use a towel and isopropanol for the final cleaning. On porous or other rough surfaces (e.g., concrete walls) a pressure washer instead of the use of solvents can be considered.

Installations Site Evaluation

Please fill in the "Installation Site Evaluation form" and send it to the Heliatek support team.

Installations Site Evaluation			
Roof/Façade Material	Material type		
	Product name		
	Product number		
Roof/Façade Information	Location		
	Inclination		
	Installation date		
	Warranty still active?	yes	no
	Photo of the Roof/ Façade	Click here to insert photo	
Roof/Façade Condition	Sufficient drainage?		
	Surface dirt?		
	Exhaust/ventilation systems?		
	Close up photo of the surface	Click here to insert photo	



Heliatek GmbH
Treidlerstraße 3
01139 Dresden
Germany

Tel: +49 (0) 351 213 034 30
Mail: sayhello@heliatek.com